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EDITORIAL

Engineering of dental tissues; reality or distant prospect

Tissue engineering envelops a fast developing multidisciplinary field. Both from a medical and dental social point of view, there is great need to safeguard tissues and organs to overcome the shortage of donor organs and to reduce the health care cost.

The ability to replace malfunctioning body parts has long been an issue of fiction and vision throughout the development of medical practice. One of the most striking examples is the legend of St. Cosmas and St. Damien, which describes the replacement of a man's gangrenous leg with the limb of a dead black man.

Apart from this legendary example, the more realistic replacement of damaged body tissue started in dentistry. The French surgeon Ambroise Paré (1510–1590) described the replacement of missing teeth by donor teeth, which were taken form "serfs". It goes without saying that this kind of early transplantation was prone to failure due to existing lack of knowledge about immunology and sterility as well as the underlying phenomena of wound healing. The discovery of the sterility principles meant an enormous step forward. However, especially, all recent progress, as made in the field of molecular sciences as well as biomaterials and chemical engineering, seem to make the original dream of complete tissue and organ replacement reality. The question is whether this suggestion is indeed true which advantages and disadvantages are associated with this technique and what the final use of tissue engineering will be for the general practitioner.

Tissue engineering can best be described as the creation of tissue. Tissue engineering is based on the tissue engineering paradigm, i.e. scaffold materials (a biomaterial in the shape of the newly to be regenerated tissue), stem cells (primordial cells which possess the potency to differentiate and proliferate in all kinds of different tissues), and signaling molecules (growth factors responsible for the differentiation of stem cells). In principle, tissue engineering can be applied for each existing tissue defect. At the moment, bone, periodontal ligament, gingiva and a complete tooth are important applications for dental tissue engineering.

1. Approaches

The applied techniques for the preparation of various tissues are more or less similar; the most important differences are the way the three different components are applied. For example, a so-called "construct" can be made by seeding stem cells in a porous carrier material, which subsequently is directly installed into a tissue defect. However, the stem cells can also be cultured for several days in the carrier material before implantation of the construct. On the other hand, when growth factors are used, the concentration of the growth factors can be varied. It is even possible, to apply two growth factors at the same time, which will induce two differentiation pathways of the stem cells. Also, a wide variety of different scaffold materials can be used. The choice of an approach or material depends on the final aim and the preference of a research laboratory or clinic. A "top three" of applied approaches is difficult to provide.

2. Advantages and disadvantages

In medicine, tissue engineering can be used especially for the treatment of large bone or skin defects and can be considered as a valuable alternative for the re-implantation of bone or skin tissue as retrieved from other body sites. In dental periodontology and implantology, tissue engineering is particularly useful for the regeneration of tissue structures, which do not possess about sufficient regenerative capacity (periodontal ligament, bone); in maxilla-facial surgery, tissue regeneration can offer a solution for large bone defects due to trauma or tumor resection. The disadvantage of the use of stem cells is that the final regenerative capacity of the construct is limited and not standardized. In addition, stem cell-based tissue engineering is very laborious and time-consuming. The disadvantage of the use of growth factors is the significant cost. Growth factors are still expensive, albeit their price has been reduced during the last two years. The major disadvantage in

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the use of growth factors is their safety. Insufficient data are available about their long-term effect and perhaps the occurrence of carcinogenesis due to transportation of the growth factor out of the defect area.

3. Challenge

Although, tissue engineering in a primitive form has already been applied in the middle ages and a significant amount of research is performed dealing with this topic, an effective and predictable clinical approach is not crystallized yet. In dentistry, bone substitutes and membranes are used for the regeneration of lost support tissues, but specific tissue engineered products of the clinical efficacy and superiority has been proven are not available. Although, there is continuous progress and development, it can be expected that a reliable application for small as well as large tissue defects has to wait for another 5–10 years. The regeneration of a complete new tooth will take a much longer space of time and is still utopian and perhaps a non-realistic ambition.

For scientists, tissue engineering offers a huge challenge: all efforts of last-decade have evidently shown that it has indeed been feasible to regenerate tissues. In view of this, the long-term goal in dentistry remains the regeneration of all relevant dental tissues with as top on the pie the regeneration of a whole tooth. This aim is feasible under the condition of the availability of sufficient research funding and establishment of dedicated research programs.

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